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ABSTRACT

Upright walking posture was successfully trained, maintained, and transferred to a new setting in a 28-year-old profoundly retarded adult. An apparatus in the S's cap and vest provided reinforcement (radio) when the S's head was up. The first four phases of the study demonstrated stimulus control in the training setting, while the next nine phases evaluated the degree to which erect posture in the transfer setting could be controlled by manipulating variables (such as frequency of walks and experimenter control of the reinforcement) in the training setting. Results indicated that maintenance of posture gains in the transfer setting was excellent across a 6-month follow-up phase. (DB)

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Stimulus Control, Transfer and Maintenance of Upright Walking Posture with a Severely Retarded Adult

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Abstract

The extent to which behavioral interventions achieve clinical significance frequently rests not simply on whether a response or set of responses can be brought under stimulus control, but whether gains made during an intervention transfer across settings, and maintain over time. Critical to this measure of significance is the extent to which manipulation of variables in one setting affect responding in other settings. The present study describes a method of obtaining stimulus control of upright walking posture with one severely retarded adult, and examines the effects varying antecedent and consequent variables in a training setting have on upright posture in a transfer setting. Results indicate that improved posture in the transfer setting was functionally related to manipulation of training setting variables. Maintenance of posture gains in the transfer setting was excellent across a six-month follow-up phase.

Stimulus Control, Transfer and Maintenance of Upright Walking Posture with a Severely Retarded Adult

Advocates of applied behavior analysis have long emphasized that behavioral interventions should produce results with ecological as well as experimental significance (Baer, Wolf & Risley, 1968; Bandura, 1969). This suggests an intervention should be evaluated not only by its functional relationship with change in behavior, but by the overall importance of that change for the subject. Two concerns in such an evaluation will be: (a) the extent to which manipulation of variables in the intervention controls responding in other settings; and (b) the degree to which control is maintained over time.

Applied researches have typically focused on variables affecting stimulus control within a particular setting. A growing body of literature, however, suggests that control across settings, and over time is gaining increasing interest (Atthowe, 1973; Kazdin, 1973; Kazdin & Bootzin, 1972; Koegel & Rincover, 1977; O'Leary & Drabman, 1971). Rincover and Koegel (1975) have demonstrated that transfer of stimulus control is more likely when the stimuli controlling behavior in a training setting are also present in the transfer setting. The same authors have also suggested that maintenance of responding in a transfer setting is improved if training stimuli and reinforcement schedules are difficult to discriminate from stimuli and reinforcement schedules in the transfer setting (Koegel & Rincover, 1977).

These data mesh well with experimental results indicating that transfer of a response from one stimulus to another will be more likely if: (a) the response is under stimulus control, and that control is not overly

precise, i.e., the slope of the generalization gradiant is not extremely steep (Terrace, 1966); and (b) the training and transfer stimuli are similar along relevant dimensions (Guttman & Kalish, 1956; Jenkins & Harrison, 1960, 1962).

The ecological validity of applied behavior analysis rests largely on the ability of behavioral engineers to describe functional relationships between manipulation of training variables and control of behavior in non-training settings. The above research suggests that transfer of stimulus control will be promoted if an intervention brings appropriate responding under control of training stimuli that are the same, or similar to, stimuli found in transfer settings. In some cases this may involve first bringing responding under control of highly intrusive training stimuli and then transferring control to stimuli naturally occurring in both training and transfer settings. Within the context of this study "transfer" will refer to acquisition of stimulus control by a set of stimuli that have been paired with a different set of stimuli which already control the targeted response (Terrace, 1963 b; Touchette, 1971).

The present study addresses this intervention model by assessing: (a) stimulus control of upright posture; (b) the effect of manipulating training stimuli on performance in a transfer setting; and (c) the extent to which improved performance in the transfer setting maintains over time.

Method

Subject

The subject was a 28 yr old male diagnosed as profoundly retarded. His IQ on the Stanford Binet was 10. Four months prior to the study the

subject was placed in a residential group home for the severely retarded, and began intensive vocational training at the Specialized Training Program, a contract assembly workshop for the severely and profoundly retarded at the University of Oregon. Prior to this placement he had spent 26 years in a state institution.

At the time of the study the subject exhibited very limited language skills, and walked with a pronounced forward lean. A medical checkup indicated his aberrant walking posture was not a function of physical abnormalities. In a two month program conducted prior to the study the subject received verbal praise for upright walking posture and was ignored when walking with poor posture. No change in the frequency of upright posture was noted during this program.

Settings

Data were collected in both training and transfer settings. The training setting consisted of a sidewalk and walkway forming the perimeter of a city block adjacent to the Specialized Training Program. Approximately 15-20 minutes were required to complete a walk on this route.

The transfer setting consisted of the route walked between the workshop and the residential group home. Due to a move of the group home during the study there was a change in the transfer setting during the early phases of the study. The new route was very similar to the initial route in length, visual stimulation, and street crossing demands. The two transfer routes differed from the training route in that they (a) required crossing of a street; (b) required only 12-15 minutes to complete; (c) were conducted with a group home staff member; (d) ended at the group home instead of the work-

shop, and (e) were always conducted at the end of the work day while training walks occurred either in the morning or early afternoon.

Apparatus

Apparatus used in the study consisted of a transistor radio, a mercury switch, velcro, a vest, a baseball cap, and electrical wire. The mercury switch was wired to the on-off mechanism of the radio, and attached by the velcro to the baseball cap. The radio was worn in a pocket of the vest. When the subject wore the vest and cap, he was able to turn the radio on or off by manipulating the forward posture of his head. The radio was chosen as a likely reinforcer because of the subject's preference for listening to a radio in free operant situations.

Observation Procedures

Four graduate students in education served as observers. One or two observers assessed the subject's walking posture during each training or transfer walk. The observer(s) walked beside and slightly behind the subject, and carried a clipboard which emitted an auditory signal every 5 sec. A binary coding system was used to score the subject's posture at the instant of each signal. A 5 sec interval was scored, "up" if the subject's head was oriented 6 m or more ahead of his feet. The interval was scored "down" if the subject's head was oriented less than 6 m in front of him. A training walk consisted of 210 five sec intervals. Transfer walks averaged from 175 to 210 intervals depending on the speed at which the subject, and his fellow workers, walked home. Following each walk the percentage of intervals scored "up" was calculated and graphed. While data for training walks were taken every work day, transfer data were gathered only two to four times a week.

The topography of the subject's walking posture generally consisted of either good or extremely poor posture. The frequency of intermediate head angles was low. This facilitated accurate, reliable observation. Data were collected in both training and transfer settings throughout the study. Care was taken to minimize all social contact between the observer and the subject both during and after walks.

Observer Agreement

Observer agreement was assessed in each phase of the study for both training and transfer walks. Agreement data were obtained by two observers accompanying the subject on a walk. Simultaneous observations of the subject's posture were taken every 5 sec.

Percent agreement between observers was used to determine observer agreement in both training and transfer walks. Agreement between observers was assessed for each 5 sec interval and the total number of agreements over agreements plus disagreements was calculated. The data collected by an observer were not included in the study until s/he met an agreement criterion of 95% over three consecutive days. One observer conducted reliability checks across all phases of the study.

Procedure

A single subject, multiple phase design was used to assess stimulus control, transfer of stimulus control and maintenance of appropriate walking posture. Though data were collected in training and transfer settings throughout the study, manipulation of independent variables only occurred in the training setting.

A total of fourteen phases were evaluated. The first four of these were designed to demonstrate stimulus control of erect walking posture in

the training setting. The next nine phases evaluated the degree to which erect posture in the transfer setting could be controlled by manipulating variables in the training setting. The final phase assessed the degree to which changes in posture maintained after training was terminated.

Procedures for the transfer walk were the same across all phases of the study. The subject walked from the workshop to the group home. He was accompanied by a group home staff member, two to five fellow residents, and an observer. No transfer setting variables were manipulated at any point in the study.

Procedures in the training walk, across the fourteen phases were as follows:

1) Baseline (BL). The subject wore all the apparatus during baseline, but the mercury switch was not attached to the radio controls. As such, the radio played at full volume throughout the walk regardless of the subject's posture.

2) Subject Control$_1$ (SC_1). During this phase the mercury switch was attached to the radio such that any forward lean causing a head orientation of less than 6 m from the subject's feet would turn the radio off. During upright posture the radio played at full volume.

3) Differential Reinforcement of Other (DRO). In this phase placement of the mercury switch was exactly reversed. The radio would only play if the subject were leaning forward, and would shut off when the subject walked with appropriate posture.

4) Subject Control$_2$ (SC_2). This phase exactly replicated SC_1.

5) Subject Control plus Two Walks (SC&TW). Procedures in this phase were the same as in the SC phases, except that two training walks were conducted (one in the morning and one in the early afternoon).

6) Subject Control plus Two Peers$_1$ (SC&TP$_1$). The subject continued to go on two training walks a day. In this phase, however, two fellow workers who were randomly selected each day accompanied him on each training walk.

7) Experimenter Control$_1$ (EC$_1$). During this phase procedures were the same as in SC&TP$_1$, except that the observer wore the vest and radio with the mercury switch attached to the clipboard. The radio could be turned on or off by tilting the clipboard. The observer turned the radio on when the subject's head was "up", and turned it off when the subject's head was "down". The subject did not wear any apparatus

8) Subject Control plus Two Peers$_2$ (SC&TP$_2$). This phase returned to procedures in SC&TP$_1$. The subject again wore the apparatus.

9) Experimenter Control$_2$ (EC$_2$). This phase replicated EC$_1$. The experimenter wore, and controlled the apparatus.

10) Radio Fading (RF). In this phase the experimenter continued to wear the apparatus. Radio volume, however, was systematically reduced. Five evenly spaced points on the volume control of the radio were marked off. The points ranged from full volume to a level identified as "just audible" by two observers. Volume was faded out across five periods: (a) during the first seven days of RF the volume level was one point below full volume, (b) during the next four days training walks were conducted with the volume reduced one more point, (c) during the next seven days the volume was lowered an additional point; (d) the next four days were run

with the radio at the "just audible" level, and (e) the final seven days of this phase were conducted with the observer continuing to wear the apparatus, but the radio was never turned on.

11) No Apparatus$_1$ (NA_1). During this phase no apparatus was worn by either the subject or the experimenter. The training walks during this phase were very similar to the transfer walks.

12) Subject Control plus Two Peers$_3$($SC\&TP_3$). This phase replicated previous SC&TP procedures. The subject once again wore the apparatus and the radio played at full volume.

13) No Apparatus$_2$ (NA_2). This phase replicated NA_1.

14) Follow-Up (FU). During this phase the subject did not go on training walks. Data from the transfer setting were collected once a week for seven weeks. Five months after training had been terminated, observation during two final transfer walks was made.

Results

During the fourteen phases of the study observer agreement was measured 55 times in the training setting and 29 times in the transfer setting. As shown in Figure 1 agreement was assessed in all phases of the study. Observer agreement averaged 95% in the training setting with a range from 79% to 99%. Agreement in the transfer setting averaged 96% with a range between 86% and 100%.

Figure 1 indicates the percent of 5 sec intervals scored "up" during the training and transfer walks across the study's fourteen phases. The phases can be divided into three main sections. The three sections provide data on stimulus control, transfer of control and maintenance of stimulus control.

Stimulus Control

The first four phases of the study make up section one. These phases comprise an ABCB experimental design, sufficient for determining (a) if improved upright posture was functionally related to intervention procedures, and (b) if the intervention procedures were functionally related to performance change in the transfer setting.

The eight days of BL data from the training walk indicate upright posture was performed at an infrequent, though stable, rate. During SC_1, however, music on the radio became contingent on upright posture, and a substantial increase in upright walking was observed. The first walk in this phase was terminated early when the subject dismantled the apparatus. Data from this aborted walk are not reported.

On the ninth day of SC_1 all members of the group home moved to a new residence. Following this move a short-lived decrease in upright posture occurred. Lack of experimental control prevents any discussion of a functional relationship between the move and reduction of erect posture on training walks. Of major note in the SC_1 phase is that appropriate walking posture during the last eight days of the phase was recorded an average of 70% of the training walk intervals. This is almost a six-fold improvement over the eight days of BL.

Following implementation of the DRO procedures the lowest levels of upright posture throughout all phases of the study were observed. The subject dropped from 73% of the training intervals scored upright on the last day of SC_1 to 5% and 4% on the two days of DRO. This effect was dramatically reversed in the SC_2 phase. The subject was observed with upright posture 84% of the intervals during the last five days of SC_2. The reversal

effect observed across the SC_1, DRO and SC_2 phases strongly suggests that stimuli provided by the apparatus were controlling walking posture.

The immediate and dramatic slope and level changes across the first four phases of the study indicate that contingent access to music on the radio was sufficient to control upright walking posture. Data from the transfer walk, however, show that training setting gains did not generalize to the transfer setting. In fact on several days during the SC phases the subject's rate of upright posture in the training setting was over three times that observed in the transfer setting.

As shown in Figure 1, upright posture in the transfer setting remained within a stable range of 9% to 29% across the first four phases. This closely resembles the rate of upright posture noted in the training setting during BL.

Transfer of Stimulus Control

The second section of the study included phases five through thirteen. These were designed to determine if manipulation of training setting variables could both maintain upright posture in the training setting and gain control of responding in the transfer setting.

In the SC&TW phase the subject went on two training walks per day. Due to the similarity of data collected on the two training walks, results are reported as the daily mean of these two walks. There was no change in performance in either the training or transfer phases during the five days of SC&TW.

The next four phases of the study (SC&TP, EC_1, $SC\&TP_2$ and EC_2) serve as an ABAB experimental design. The major dependent measure across this

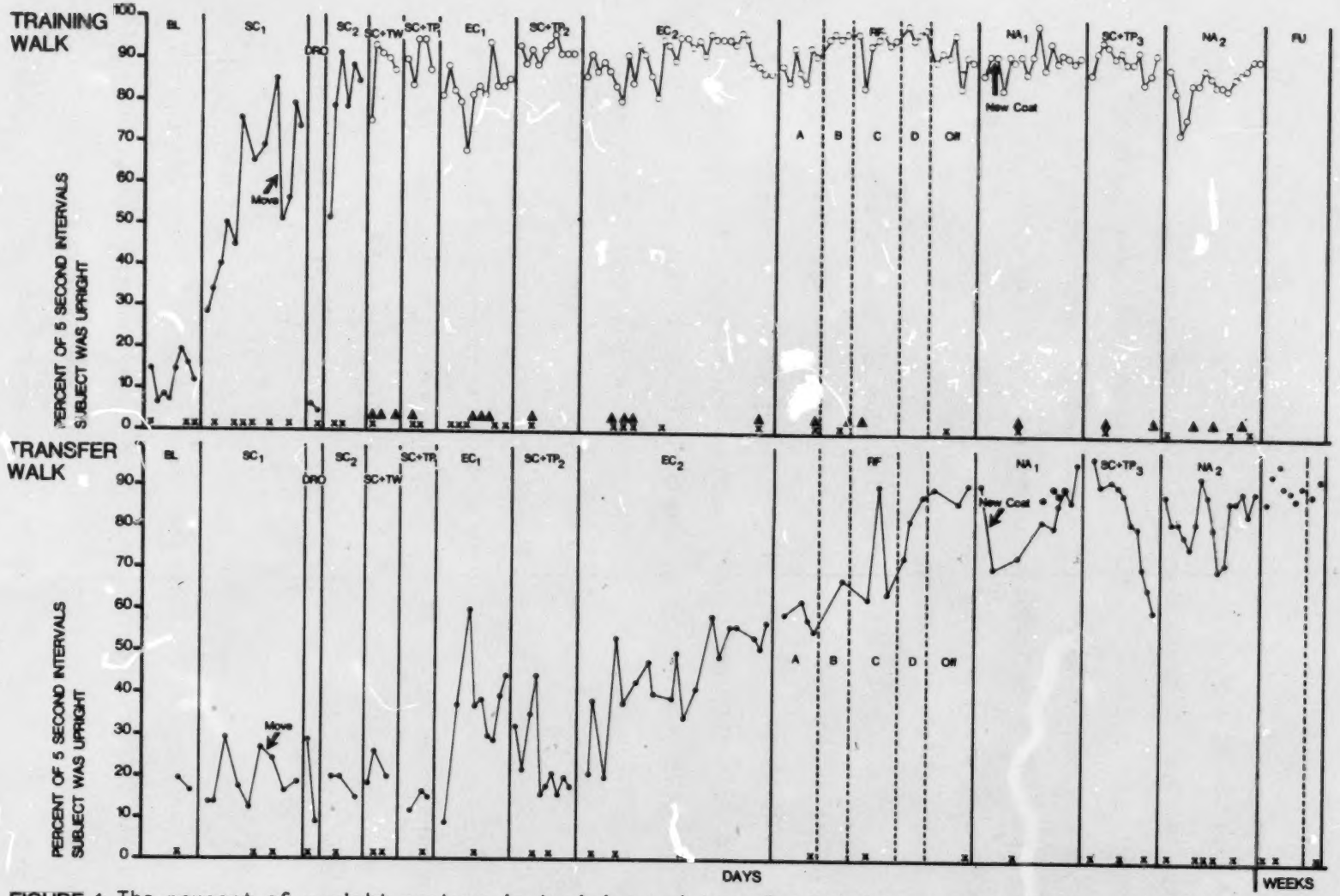

FIGURE 1: The percent of upright posture in training and transfer settings across days. Xs indicate days when reliability was taken on initial walks. ▲s indicate when reliability was taken on the second training walk. Open circles represent the daily average percentage of the two training walks. Asterisks indicate rescoring of data with intervals in which the subject was looking at his coat discarded.

design was the rate of upright posture in the transfer setting. As can be seen in Figure 1, performance remained stable in both settings when two peers began accompanying the subject on training walks (phase $SC\&TP_1$). When the experimenter wore the apparatus (EC_1), however, there was a slight loss of control in the training setting and a doubling in the rate of upright posture in the transfer setting.

It is important to note that the loss of control in the training setting and improved performance in the transfer setting were paired not only with removal of the tactile stimuli provided by the apparatus, but by two other subtle changes. First, during the EC_1 phase the on-off control of the radio was manipulated by the observer. As a result, the latency between change in head posture and change in access to music was slightly longer in the EC_1 phase than in previous phases. A second change was the physical proximity of the subject to the radio. During the initial phases of the study the radio was in the breast pocket of a vest the subject wore. During EC_1 the vest and radio were worn by the observer, hence, the radio was approximately four to five feet further away from the subject, and it is assumed some loss of volume was perceptible. The present design does not allow effects from each of these manipulations to be assessed independently.

When the subject once again wore the apparatus in the $SC\&TP_2$ phase, there was an immediate increase and stabilization of upright walking posture in the training setting. A decrease in performance, however, was observed in the transfer setting. During the last six days of $SC\&TP_2$ the subject walked with upright posture an average of only 18% of the time.

Implementation of the EC_2 phase was followed by initial, slight decrease in level and increase in variability of upright training posture. Soon, however, training data indicated consistent, stable, rates of upright performance. Transfer performance gradually improved and then stabilized during EC_2. Data from the last seven days in the transfer setting fell within a range of nine percentage points. This low level of variability was felt to indicate stability of performance. If the transfer data for the EC_2 phase alone is assessed this stability criterion appears reasonable. When the same data is viewed within the context of $SC\&TP_2$, EC_2 and RF data, however, the overall upward trend of the data suggests this arbitrary stability criterion may have been insufficient.

Transfer data across phases $SC\&TP_1$, EC_1, $SC\&TP_2$ and EC_2 indicates evidence of an ABAB reversal effect. Change in subject performance in the transfer setting systematically followed manipulation of training variables. This suggests that stimulus changes associated with having the observer, rather than the subject, wear and manipulate the apparatus, were in fact functionally related to performance in the transfer setting.

Data from the RF phase show highly stable rates of upright posture in the training setting, and progressively improving rates of upright posture in the transfer setting. The last four days of transfer data averaged 87%. This is nearly equal to the rate of upright posture observed on training walks. The systematic fading of radio volume in the RF phase fits the model of a changing criterion design (Hartmann & Hull, 1976). There is insufficient transfer data, however, to assess the RF phase using a changing criterion analysis. In addition, the data that were collected do not fol-

low the pattern predicted by that design. As such, this phase of the study lacks experimental control.

While the NA_1, $SC\&TP_3$ and NA_2 phases are clearly not independent of preceeding manipulations, they can be viewed from the perspective of a BAB experimental design. In the seventeen days of the NA_1 phase the subject maintained a high rate of upright posture during training walks even though the radio apparatus was not present. As can be seen in Figure 1 a substantial drop in the level of upright posture in the transfer setting followed implementation of the NA_1 phase.

On the second day of NA_1 the subject received a new coat. The coat was always worn during transfer walks, but only worn occasionally during training walks. Observers reported that the majority of transfer intervals scored "down" on the first two transfer walks after the coat was purchased were due to the subject orienting toward, and manipulating the pockets of his coat. To avoid this potential confound, data for the next four transfer walks are presented both with intervals when the subject was orienting toward pockets scored as "down", and with those intervals discarded. The decreasing discrepancy between these two methods of scoring suggests that data for the NA_1 phase may have been less variable had the subject not received a new coat.

The last six days of the NA_1 phase demonstrate substantial stimulus control of upright posture in both settings. When $SC\&TP_3$ procedures were implemented training setting data did not alter. A marked change in slope can be seen, however, in data from the transfer setting. During the ten days of this phase upright posture dropped in near linear fashion from 97%

to 59%. This suggests a substantial loss of stimulus control by those stimuli which had come to control upright posture in the transfer setting. A return to NA conditions in the NA_2 phase was followed by a return to high rates of upright posture on the transfer walk. During the last five days of NA_2 an average of 86% of the intervals were scored "up" within a range of only five percentage points.

The reversal effect noted across the NA_1, $SC\&TP_3$, and NA_2 phases again indicates that manipulation of training setting variables was functionally related to performance during transfer walks. Upright posture in the NA_1 phase was controlled by non-apparatus related stimuli in both training and transfer settings. Presentation of the apparatus, however, appeared to have a debilitating effect on this control during transfer walks. It is unclear what effect presentation of the apparatus related stimuli had on the control exerted by non-apparatus related stimuli in the training setting.

Maintenance

The final section of the study contained only the FU phase. This phase evaluated maintenance of improved posture in the transfer setting after training walks were terminated. Figure 1 presents data collected at weekly intervals over the seven weeks after training ended. In addition two final points were collected at 21 and 22 weeks respectively after training walks had been terminated. Results from these walks indicate the subject maintained his high rate of upright posture at a level equal to or better than that observed during the previous NA_1 and NA_2 phases. These data are impressive given that no social or edible rewards were contingently delivered for

upright posture, and no "booster" training sessions were run.

Discussion

One determinant of the control a stimulus will exert over a response is the extent to which that stimulus sets the occasion for a contingent relationship between the response and a consequence (Skinner, 1969).[1] It is likely that those training setting stimuli in the present study, which set the occasion for a contingent relationship between upright posture and music from the radio, came to control upright walking during the early phases of the study. That this control was not initially exhibited in the transfer setting suggests either: (a) an initial increase in upright posture occurred outside the training setting but was extinguished (Koegel & Rincover, 1977), or (b) the stimuli controlling upright posture in the training setting were not present in the transfer setting (Rincover & Koegel, 1975).

Training data from the SC_1, DRO and SC_2 phases indicate the subject's initial upright, training posture was controlled by stimuli provided by the apparatus. It is likely the poor rate of upright posture observed in the transfer setting during SC_1 and SC_2 phases was functionally related to the absence of these controlling stimuli. To facilitate upright posture in the transfer setting an attempt was made to transfer control to stimuli present in both training and transfer settings. Numerous studies suggest that a response controlled by one set of stimuli can be brought under control of a new set of stimuli by presenting both the new and original stimuli simultaneously, and then gradually fading the originals (Fields, Bruno, & Keller, 1976; Sidman & Stoddard, 1967; Terrace, 1963 a, b; Touchette, 1971; Westbrook & Miles, 1970). In the present study it was felt the proprioceptive,

visual and/or tactual stimuli naturally present in both settings could control upright walking if stimuli provided by the apparatus were faded out.

The EC_1 phase marks the first manipulation in which some stimuli provided by the apparatus were removed. Transfer data from the EC_1 phase indicates a marked improvement in posture over the low rates observed in the previous six phases. As noted earlier this effect may have been related to latency or proximity changes in the contingent delivery of music. It is also likely, however, that the tactile stimuli provided by the apparatus had come to partially control upright posture. Removal of the tactile stimuli may have served to partially fade controlling stimuli provided by the apparatus and facilitate transfer of some control to new stimuli naturally present in both training and transfer settings. If the new stimuli came to partially control upright walking in the training setting, and if these stimuli were also present in the transfer setting, partial control of upright posture in the transfer setting would be expected.

Evidence of an ABAB reversal effect observed across the $SC\&TP_1$, EC_1, $SC\&TP_2$ and EC_2 phases indicates that the increase in upright posture in the transfer setting during EC phases was functionally related to whether the subject or the observer wore the apparatus. Though posture in the transfer settings improved during the EC phases, it remained half that observed in the training setting. This suggests that transfer setting stimuli only partially controlled upright walking at this phase in the study. Not until the auditory stimuli provided by the radio were faded out in the RF phase did transfer setting stimuli come to control responding at the same level as training

setting stimuli. It is possible the auditory stimuli from the radio exerted substantial control over upright walking. This control may have limited tne transfer of control to new stimuli. The present design does not, however, provide sufficient experimental control to evaluate this possibility.

Recent research suggests that transfer of stimulus control during fading is a gradual process (Ray & Sidman, 1970; Sutherland & Mackintosh, 1971). As the stimuli controlling a response are faded, both new stimuli and the partially faded original stimuli exert control. When the original stimuli are completely faded the new stimuli alone control responding (Fields, Bruno, & Keller, 1976). The partial control of upright posture during EC phases may well reflect the early stages in this model of transfer. Responding in the training setting may have been controlled by both the auditory stimuli provided by the apparatus, and other stimuli natural to the setting. If some of these new controlling stimuli were also present in the transfer setting, improved posture in the transfer setting would be expected.

In the last part of the RF phase and the two NA phases, the subject exhibited nearly equal rates of upright walking in the two settings. This high rate of responding occurred even though the stimuli which had controlled upright posture in the early phases of the study were not present in either setting. These data argue that control of upright posture in the training setting had transferred from apparatus-specific stimuli to some other set of stimuli present in both training and transfer settings. This would be consistent with operant research on stimulus blocking. Research

examining the effects of blocking indicates that previous discrimination training with one stimulus from a group of simultaneously presented stimuli will reduce the control acquired by other stimuli in the group (Fields, Bruno, & Keller, 1976; Rescorla & Wagner, 1972). The conditioning of upright posture to apparatus specific stimuli during the initial phases of the study may have been functionally related to the limited acquisition of control by other stimuli during fading.

Blocking has generally been discussed only with reference to acquisition of stimulus control by new elements of a compound stimuli. A similar process, however, may have also affected performance in the SC&TP_2 and SC& TP_3 phases. During these phases, stimuli previously controlling responding in the transfer setting appeared to lose that control, even though stimulus manipulations only occurred in the training setting. The addition of apparatus specific stimuli may have not only functioned to prevent new stimuli from acquiring control, but actually reduced the control that had already transferred. Further analysis of this phenomenon is necessary.

The present study demonstrates that a profoundly retarded adult was able to gain control of behavior as complex, and seemingly involuntary, as walking posture. Of additional significance is the demonstration that the subject's improved performance transferred to a setting where training never occurred, and maintained over a substantial time period. While no attempt was made to systematically identify variables affecting maintenance, it is possible there were events other than music which came to function as reinforcers for upright posture.

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Footnotes

[1]Recent operant research requires at least a footnote be added in recognition of the non-trivial role classical conditioning may play in the acquisition of stimulus control (Schwartz & Gamzu, 1977).